

**Risø High Dose Reference Laboratory**

**Note on NPL comparison 2016, verification of calibration, electrons  
Alanine dosimeter batch AX600**

Procedure: HDRL-P-18: Comparison program – external:

Irradiation of NPL dosimeters and Risø HDRL dosimeters at a 10 MeV electron accelerator (HDRL-I-48).

Irradiation at Sterigenics, Esbjerg 2016.07.26.

NPL alanine reference dosimeters: Batch 72, 1067-1072, in holder type E (standard holder).

HDRL dosimeters: Harwell alanine pellets, batch AX600, 1308-1313, in standard holder.

Kodak alanine film, batch 312 set 12, six sets of three films.

Geometry: Risø HDRL standard absorber for irradiation of dosimeters at electron accelerators. Absorbers were placed in aluminum trays for irradiation at conveyor.

Calorimeters used solely to measure start and end temperatures of irradiations.

**Irradiation data:**

| Phantom | NPL dosim. | HDRL pellets | HDRL films     | Req. dose | Temp. (start) | Temp. (end) |
|---------|------------|--------------|----------------|-----------|---------------|-------------|
| #       | 71         | AX600        | 312-12         | [kGy]     | [°C]          | [°C]        |
| 10A     | 1067       | 1308         | 4083,3627,3475 | 10        | 20.8          | 28.7        |
| 10B     | 1068       | 1309         | 3522,3643,3623 | 10        | 20.8          | 28.7        |
| 20A     | 1069       | 1310         | 3516,3491,3994 | 20        | 21.3          | 36.6        |
| 20B     | 1070       | 1311         | 3993,3907,3911 | 20        | 21.6          | 36.7        |
| 40A     | 1071       | 1312         | 4018,3397,3898 | 40        | 21.4          | 51.0        |
| 40B     | 1072       | 1313         | 4103,3507,3616 | 40        | 21.4          | 51.0        |

**Measurements:**

Pellets, AX600:

- |   |             |               |
|---|-------------|---------------|
| 1 | Measured:   | 2016.08.12    |
|   | Instrument: | Bruker e-scan |
| 2 | Measured:   | 2016.08.19    |
|   | Instrument: | Bruker EMX    |

Results from pellets measured on e-scan were reported to NPL in certificate 16C-71 (2016.08.15).

Kodak alanine films, 312-12:

- |   |             |                |
|---|-------------|----------------|
| 1 | Measured:   | 2016.08.19     |
|   | Instrument: | Bruker EMS-104 |

**Results:**

Results contained in NPL certificate for alanine dosimeter measurements 2016060482/1 received 2016.09.16.

**1 Pellets measured on e-scan (blind comparison)**

Uncertainty associated with NPL transfer dosimeter readings:

$$U(\text{NPL}) = 2.6\% \text{ (k=2)}$$

Uncertainty associated with HDRL dosimeter readings (e-scan). Excluding NPL transfer dosimeter uncertainty:

$$U(\text{HDRL}) = 1.88\% \text{ (k=2)}.$$

| Phantom | NPL Dose | HDRL dose (e-scan) | %Difference | E-value |
|---------|----------|--------------------|-------------|---------|
| #       | [kGy]    | [kGy]              | [%]         | k=2     |
| 10A     | 9.97     | 10.21              | 2.4         | 0.74    |
| 10B     | 10.01    | 10.18              | 1.7         | 0.53    |
| 20A     | 20.0     | 20.3               | 1.5         | 0.47    |
| 20B     | 20.1     | 20.4               | 1.5         | 0.46    |
| 40A     | 40.5     | 41.1               | 1.5         | 0.47    |
| 40B     | 40.0     | 40.5               | 1.3         | 0.41    |
|         |          | <b>Average</b>     | 1.7         | 0.5     |

## 2 Pellets measured on EMX (blind comparison)

Uncertainty associated with HDRL dosimeter readings (EMX). Excluding NPL transfer dosimeter uncertainty:

$$U(\text{HDRL}) = 1.81\% \text{ (k=2)}.$$

| Phantom | NPL Dose | HDRL dose (EMX) | %Difference | E-value |
|---------|----------|-----------------|-------------|---------|
| #       | [kGy]    | [kGy]           | [%]         | k=2     |
| 10A     | 9.97     | 10.18           | 2.1         | 0.66    |
| 10B     | 10.01    | 10.25           | 2.4         | 0.75    |
| 20A     | 20.0     | 20.1            | 0.4         | 0.13    |
| 20B     | 20.1     | 20.2            | 0.7         | 0.22    |
| 40A     | 40.5     | 40.6            | 0.3         | 0.11    |
| 40B     | 40.0     | 40.4            | 1.0         | 0.31    |
|         |          | <b>Average</b>  | 0.1         | 0.36    |

### Comments:

All E-values (both instruments) are less than 1, and the result of the comparison is acceptable. However we note that all measured doses at HDRL are numerically greater than those from NPL for the same irradiation geometry, and this will be investigated further.

### 3 Alanine films measured on EMS-104 (blind comparison)

Uncertainty associated with HDRL dosimeter readings (e-scan). Excluding NPL transfer dosimeter uncertainty:

$$U(\text{HDRL}) = 1.97\% \text{ (k=2)}.$$

Dosimeters measured using both average irradiation temperature and maximum irradiation temperature.

#### 1: Correction to response using average temperature

| Phantom | NPL Dose | HDRL dose (EMS-104), mean temp | %Difference | E-value |
|---------|----------|--------------------------------|-------------|---------|
| #       | [kGy]    | [kGy]                          | [%]         | k=2     |
| 10A     | 9.97     | 10.13                          | 1.6         | 0.49    |
| 10B     | 10.01    | 10.09                          | 0.8         | 0.24    |
| 20A     | 20.0     | 20.4                           | 2.2         | 0.67    |
| 20B     | 20.1     | 20.0                           | -0.4        | 0.14    |
| 40A     | 40.5     | 41.8                           | 3.2         | 0.99    |
| 40B     | 40.0     | 41.8                           | 4.5         | 1.36    |
|         |          | <b>Average</b>                 | 2.0         | 0.65    |

#### 2: Correction to response using maximum temperature

| Phantom | NPL Dose | HDRL dose (EMS-104), max temp | %Difference | E-value |
|---------|----------|-------------------------------|-------------|---------|
| #       | [kGy]    | [kGy]                         | [%]         | k=2     |
| 10A     | 9.97     | 10.07                         | 1.0         | 0.30    |
| 10B     | 10.01    | 10.04                         | 0.3         | 0.09    |
| 20A     | 20.0     | 20.2                          | 1.0         | 0.31    |
| 20B     | 20.1     | 19.8                          | -1.6        | 0.49    |
| 40A     | 40.5     | 40.7                          | 0.4         | 0.14    |
| 40B     | 40.0     | 40.7                          | 1.6         | 0.50    |
|         |          | <b>Average</b>                | 0.5         | 0.30    |



2016.08.23

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**Comments:**

1: It is clear that the results from film measurements are much improved if like the pellets, they are measured with a correction to the maximum irradiation temperature. This will be implemented immediately. However very few high-energy irradiations use the dosimeter films, and the change is within the expected overall uncertainty, so there are no issues regarding incorrect dose.

2: With the maximum irradiation temperature, the E-values are all significantly less than 1.0, so the comparison is acceptable.

Mark Bailey

Arne Miller

24 August 2016